UNITED STATES
DEPARTMENT OF AGRICULTURE
DEPARTMENT CIRCULAR 419

Washington, D. C. | July, 1927

GROUPING OF SOILS ON THE BASIS OF MECHANICAL ANALYSIS

R. O. E. DAVIS
Chief, Soil Physics Division
and
H. H. BENNETT
Inspector in Soil Survey, Bureau of Soils

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DESIGNATIONS OF SOIL CLASSES

The most common groups of soils are sand, loam, and clay. These class names indicate primarily the differences that are popularly associated with the textural characteristics of soils. Roughly, the class name sand designates the predominance of coarse material; clay, the predominance of fine material; and loam, a more or less balanced mixture of both coarse and fine materials.

The Bureau of Soils early established limits for the proportions of the main mechanical constituents in soils. These limits were more or less arbitrary, being made to conform to the textures designated in the field as sand, loam, clay, etc. A few changes and additions have been made since then, but the classes in use in the bureau have never been clearly defined. Certain changes in the classes have recently been suggested; namely, that the number of textural groups be reduced and the limits in the proportions of the separates be more definitely designated. It seems advisable, therefore, to present the classification now used by the Bureau of Soils and to discuss some of its features.

To the first general groups of soils there have been added other classes having more exactly defined limits with respect to the pro-

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portions of the grains of different sizes, until now from 15 to 20 designations or classes are in common use. Efforts have been made to indicate diagrammatically or otherwise the physical composition of the soils of these classes by shading that shows the proportions of the grains of different sizes within arbitrary limits (*1*, *7*)[1]; by a continuous curve that shows the distribution of the particles of various sizes (*9*); and by points on a triangular diagram so placed that the position of one will indicate the mechanical composition of a particular class (*4*; *6*, *p. 157*). Attempts have also been made to show in a diagram the adaptation of certain crops to certain soil classes (*9*). It has been found necessary, however, to refer to specific field results in order that the value may be understood of such indicated relationships as must be interpreted in relation to climate and to drainage and topography of particular areas. Nevertheless, certain broad characterizations of soils are usually associated with their textures.

THE NEED FOR CLASSIFICATION

The need for the designation of soil classes was felt first by field men. The class to which a soil belonged was judged by the "feel" when some of the surface material was rubbed between the fingers. The men who did the early survey work observed closely the textural designations used by farmers. They soon learned that there was sometimes a surprising inconsistency in the meaning of a term as it was used in different localities to designate soils of similar composition. For example, in a section where the soils were generally clayey, soils no coarser than a silt loam were called sandy loam, and in localities where sandy soils predominated, soils having a silt-loam texture were referred to as clayey soils.

The Bureau of Soils, from the beginning of the soil survey, has collected many samples which were examined and given class names in the field and then sent to the laboratory for mechanical analysis. At first the designation of the different classes was based on the general experience of the field men. Later the limits for the proportions of the particles of different sizes in each class were more closely drawn to correspond to certain mechanical compositions which were regarded as standard or typical. These limits have been changed from time to time as wider experience dictated. In general, however, the terms "clay," "loam," and "sand" still carry fairly definite meanings with respect to the mechanical composition of soil materials. In view of this fact, the definitions of these class terms should harmonize with the general understanding of them.

THE WHITNEY DIAGRAM

After many thousands of soil samples had been analyzed by the Bureau of Soils, some slight changes in the original classes were proposed by Whitney (*8*, *p. 13*) to make them conform to the findings of the field men. This was done in the following manner: The class designations made by experienced men who collected the samples were accepted as correct, and the proportions of silt and clay par-

[1] Reference is made by italic numbers in parentheses to Literature cited, p. 13.

ticles, as determined by mechanical analyses, were plotted on a right-angled diagram whose abscissa and ordinate represented proportions of clay and silt to 100 per cent. For example, the analyses of all soil samples designated as loams were selected, and dots representing the proportions of silt and clay they contained were given their places on the diagram. When all the proportions were thus plotted two areas were marked off on the diagram, one including all the dots representing the silt proportions and the other all the dots representing the clay proportions. This process was repeated for each soil class. Naturally there was some overlapping of the areas represent-

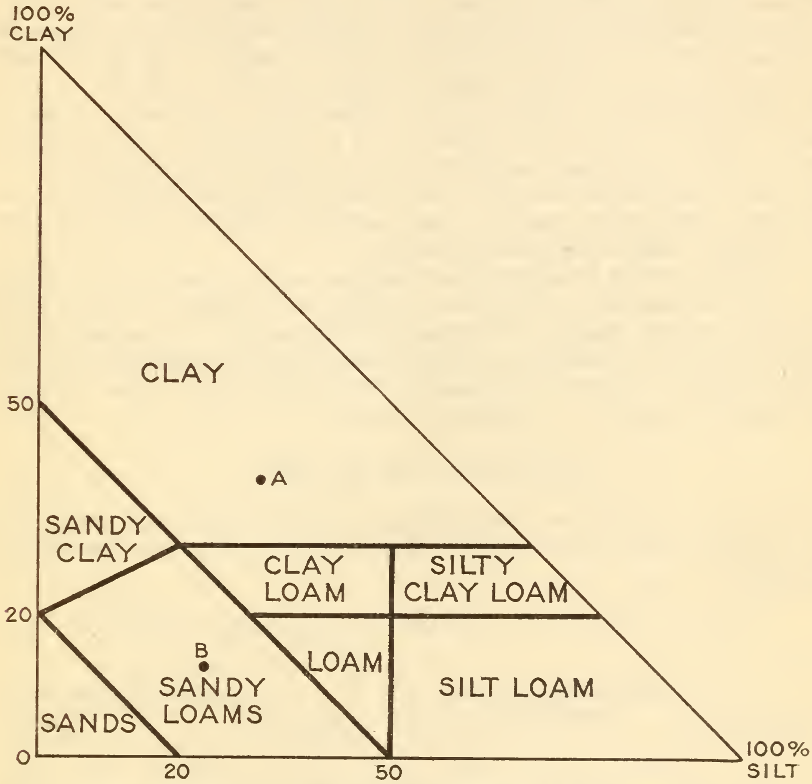

FIG. 1.—The Whitney diagram, showing classification of soils according to silt and clay content

ing the different classes, making it necessary to determine rather arbitrary boundaries between them. In each case the boundary was drawn in accordance with the number of times the field men agreed on the name of the class. This explains the origin of the Whitney right-angled triangle, with its definite areas representing the composition of eight principal soil classes. (Fig. 1.)

Only the proportions of silt and clay are shown on the Whitney diagram. The proportion of sand may be ascertained by subtraction. The fact that the proportion of sand in the various soils is not represented in this diagram constitutes the main objection to its use. Inasmuch as soil texture is a quality which is determined by the

proportions of sand, silt, and clay in a sample of soil material, it seems best to show the physical composition of the soil classes in a diagram in which the proportions of these three mechanical constituents may be represented.

PROPOSED CHANGES

Recently Beaumont and Sessions (*2*) proposed a continued use of the Whitney diagram by simplifying the terminology. They recommend that the number of classes be reduced to four; namely, loam, sandy loam, silt loam, and clay loam. This proposal is radical, as some of the classes would have to include many soils which differ widely in mechanical composition. The following are the principal reasons given for reducing the number of classes: (1) Loamy soils predominate in the United States: (2) confusion is likely to arise from the double meanings of the terms clay and sand, which at present apply both to soil classes and to particles or separates of certain sizes; (3) field examinations are not sufficiently accurate to determine the difference in classes which differ but slightly in mechanical composition; and (4) fine textural differences in soils have no significant effect on plant growth.

According to the Whitney triangle, the proportions of sand, which may be obtained by subtraction, include all grades of sand, from very fine to very coarse. It would add interest to a diagram if the proportions of the different grades of sand could be shown with those of silt and clay. But this would be impossible, even by the use of an equilateral triangle, on a plane diagram.

PRINCIPAL SOIL CLASSES

In Table 1 are shown the limits in the proportions of sand, silt, and clay for each of the 10 main classes of soil, based on mechanical composition.

TABLE 1.—*Mechanical composition of the principal soil classes*

Soil classes	Limits in the proportions of the soil separates			Soil classes	Limits in the proportions of the soil separates		
	Sand	Silt	Clay		Sand	Silt	Clay
	Per cent	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*
Sand	80 to 100	0 to 20	0 to 20	Sandy clay loam	50 to 80	0 to 30	20 to 30
Sandy loam	50 to 80	0 to 50	0 to 20	Clay loam	20 to 50	20 to 50	20 to 30
Silt loam	0 to 50	50 to 100	0 to 20	Silty clay	0 to 20	50 to 70	30 to 50
Loam	30 to 50	30 to 50	0 to 20	Sandy clay	50 to 70	0 to 20	30 to 50
Silty clay loam	0 to 30	50 to 80	20 to 30	Clay	0 to 50	0 to 50	30 to 100

It will be noted that the areas on Whitney's diagram are symmetrical. Furthermore, there is no silt-class area to correspond with the sand-class area, owing to the fact that practically no soils are classed as silt, because no soils have as high proportions of silt as the sand soils have of sand. Seldom is a soil material with more than 80 per cent of silt found. Logically, soils with large proportions of silt would be represented on the diagram in an area indicating a composition up to 20 per cent of sand, 20 per cent clay, and from 80 to

100 per cent of silt; but this class has been omitted from the diagram for the sake of conforming to actual conditions in the field. A soil composed almost entirely of silt particles is less likely to be found than one composed entirely of sand particles. It should also be pointed out that soils approaching 100 per cent of clay are practically unknown, so far as American soils are concerned. Not many soils contain more than 65 per cent of clay, although a few from tropical regions have been shown by analysis to approach close to 100 per cent of clay.

It is evident also that the soils of one class will vary in mechanical composition and that certain soils having compositions close to the boundary between two classes can not be readily distinguished, except by analysis, from those on the other side of the boundary. Thus, a soil typical of a class will not have a composition as indicated by a point close to the boundary between two of the diagram areas.

Although it may be true that the loam class includes more soils than any other class, it is also true that there are many loamy soils covering large areas, which are so different from loams in their properties as not to warrant being classed under loam. Such a classification would give an entirely wrong impression of their real textural characteristics, which are not easily mistaken in the field. Furthermore, the names "sandy loam," "silt loam," and "clay loam" for soil classes acquired meanings quite different from those of "sand," "silt," and "clay," the names of the three groups of soil particles. The first set of terms implies soil qualities which may be easily determined in the field. The number of soils having a very high proportion of either clay or sand is not small, and the fact that such soils are found necessitates some provision for them in the classification based on mechanical composition. For example, the Bureau of Soils has surveyed 9,167,000 acres of land classed as Norfolk sand and 6,353,000 acres classed as Norfolk fine sandy loam. These soils are so different in their characteristics that it would be unwise to class them all as sandy loams.

The confusion that may result from the use of the terms "clay" and "sand" to designate both size of soil particles and class of soils seems even less objectionable than the inaccuracy of grouping together in one class soils which cover large areas and which have distinguished textural characteristics. It is common for a word that carries more than one meaning to be used freely without confusion as to which meaning is indicated. To the student of soils there will be but little confusion as to the meaning intended by the use of the terms "sand" and "clay." If there is any probability of misunderstanding, it would be better to use the descriptive terms "sand separates" and "clay separates" to designate these classes of particles and the terms "sand" and "clay" to indicate classes of soil. In any event the objection on the score of confusion does not seem to be very serious.

A field examination may not suffice to distinguish between soils that are very similar in texture but fall in different classes according to mechanical analysis. For example, it would be difficult to determine accurately by field methods the boundary line between adjoining areas of Norfolk sandy loam and Norfolk fine sandy loam. It is doubtful that the elimination of some of the classes would overcome

the difficulty of differentiating under field conditions between some soil classes, as loam and sandy loam.

SUBORDINATE CLASSES AND PHASES

Other textural divisions, or subordinate classes, determined by the proportions of the sand particles of different sizes in a soil sample. have been recognized. These subordinate classes are designated as coarse sand, fine sand, very fine sand, loamy coarse sand, loamy sand, loamy fine sand, loamy very fine sand, coarse sandy loam, fine sandy loam, and very fine sandy loam. The sandy classes may be grouped according to certain limits in the range of the proportion of silt and clay. It is impossible to represent these groups graphically on a plane-coordinate diagram, as at least four grades of particles of different sizes are indicated in each group.

When stones and gravel are present in quantities sufficient to be especially noticeable, their presence should be indicated. This is done by adding the term " stony " or " gravelly " to the name of the soil in which these materials abound. Where fragments of slate or shale are present in the soil in considerable quantity the term " slate " or " shale " is used. Thus we have stony loam, stony clay, gravelly silt loam, shale loam, slate loam, etc. The terms " gravel " and " stone," as here used, refer to either rounded or angular rock of any lithologic character. Those more than 4½ inches in diameter are called stones, and those of smaller diameter, gravel. Slate and shale, as descriptive terms, are used only when fragments of slate or shale rocks are angular and occur as characteristic flat plates.

The term " phase " implies a variation in a soil type that is of less importance than any distinguishing characteristic designating a soil series. When there is no essential difference in the mechanical make-up of the soil material, the term is commonly used to designate accentuated relief in local areas, rather marked variations in the drainage of soil, areas of comparatively shallow or deep soils, eroded lands, etc.

RELATION OF SOIL TEXTURE TO CROP ADAPTATION

Efforts have been made by Whittles (*9*) to show, by use of the equilateral triangle, the adaptation of certain crops to certain soil classes. Only in the most general terms, however, can it be said that soils of certain textures are suitable for certain crops. The location of soil, with respect to both altitude and climate, influences its crop adaptability. Generally, however, soils with more than 50 per cent sand, constituting the " light " soils, are adapted to the raising of early vegetables. Soils with less sand and more clay are of the " medium " or " heavy " classes, ranging from those best suited to corn, potatoes, tobacco, cotton, and fruit to those best suited to grass and other dairy-farming crops.

It is not to be understood that soils which are similar in mechanical composition will always be adapted to the same crops. In considering the adaptability of any soil to a particular crop, much consideration must be given to climatic conditions. In fact, climate is a primary factory in crop adaptation. For example, cotton may be grown successfully on soil of nearly any type except the very deep

sandy types or the very hard clays, but its production in the United States is restricted to the Southern States, regardless of soil texture, because of the length of the frost-free period. Where limiting conditions as to the climatic factor are approached, as in the northern part of the Cotton Belt, the selection of proper soils for particular crops becomes more important.

It may be true that fine textural differences have no significant effect on plant growth, but in grouping soils into classes according to texture it is necessary to consider the physical composition only. The effect on plant growth can not be taken as a criterion in such a soil classification, because plant growth is influenced by many other factors, any one of which may have more influence than a slight difference in texture.

DEFINITION OF TERMS

The field man must be constantly on guard to avoid confusing the terms "texture," "structure," and "consistence." Texture is that quality of soil material resulting from its proportionate composition of sand, silt, and clay. When some soil material is rubbed in the hand, the feel of it designates its texture as light or sandy, heavy or clayey, silty, loamy, clay loam, silty clay loam, etc. Structure is the arrangement of the constituent particles in soils which, for example, may be described as granular, crummy, columnar, single grained, etc. Consistence means the firmness of soil or its resistance to deformation when moist, as compact, tough, tenacious, plastic, friable, etc. Consistence is affected by soil structure and mechanical composition.

EQUILATERAL TRIANGLE METHOD

Subsequent to Whitney's proposal of the right-angled triangle method the use of an equilateral triangle to show completely the mechanical composition of the various soil classes was suggested. Wilsdon (*10*) proposed the use of such a triangle in 1919, and Whittles (*9*), reviewing the classification schemes, has suggested one scheme in which the agronomic use of his soil classes is indicated on an equilateral triangle. Boyd (*4*) and Rose (*6, p. 157*), of the Bureau of Public Roads, have used the equilateral triangle to aid in the classification of soil materials suitable for road building, but their classes do not agree with those generally accepted by soil investigators.

Each of the schemes for showing graphically the mechanical composition of the various soil classes has some objectionable features. From a consideration of them, a new scheme using an equilateral triangle for such illustrative purposes has been devised. It has been pointed out that the triangular method of presentation limits the number of classes of soil separates to three. In order to make an equilateral triangle workable, the sides must represent zero proportions of sand, silt, and clay, and the apexes opposite, 100 per cent proportions of these three soil constituents.

As the method of mechanical analysis in use by the Bureau of Soils involves the separation of the soil material into seven groups within different size limits, some combination must be effected in order to condense them to three. It is proposed, therefore, to use

one group of material between the limits 2 to 0.05 mm., and call it sand. The other two groups are silt, 0.05 to 0.005 mm., and clay below 0.005 mm. It is well recognized that the material of smallest particle size exerts a great influence on the properties of a soil and as a rule determines its character. But Keen (*5*) has shown that the physical properties of the group of particles finer than 0.002 mm. in diameter are not measurably affected by including with that group particles as large as 0.005 mm. in diameter.

The proportion of sand, silt, and clay for the main soil classes are shown on the triangle in Figure 2.

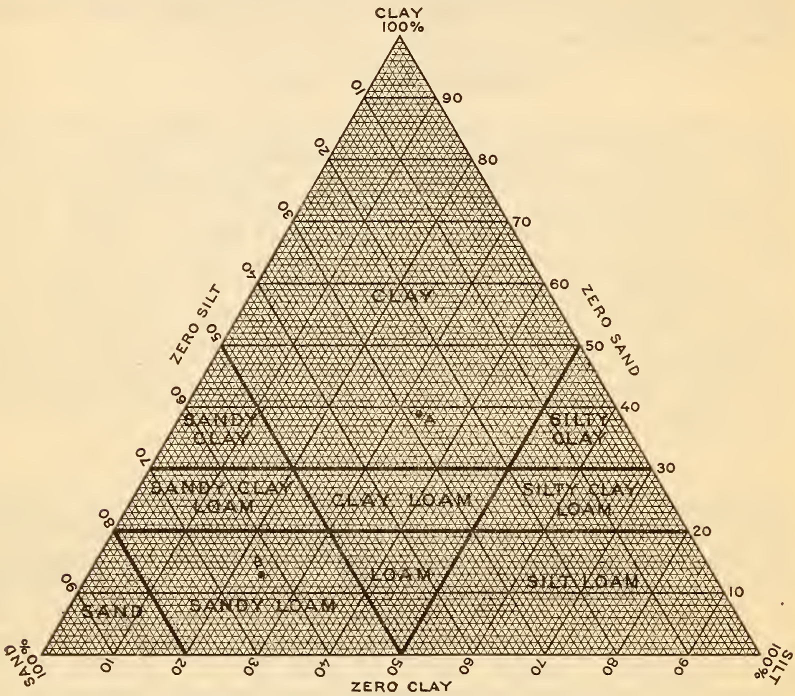

FIG. 2.—Diagram showing 10 of the main soil classes in relation to their percentage composition of sand, silt, and clay

In Figure 2 the limits in the proportions of the silt and clay constituents are the same as those indicated in Figure 1, except that it was found desirable to include in Figure 2 two additional classes—sandy clay loam and silty clay. This diagram therefore gives directly not only the limiting proportions of silt and clay but also those of sand for each class designated. The limits in the diameter range for the different grades of particles correspond to those used in the Bureau of Soils. The sand particles range from 2 to 0.05 mm. in diameter, the silt particles range from 0.05 to 0.005 mm., and the clay particles are less than 0.005 mm. in diameter.

In studying Figure 2 it is important to remember that the size of a class area on the triangle bears no relation to the proportionate distribution of that soil in nature.

HOW TO USE IT

The use of the equilateral triangle to determine the classes from mechanical analyses may be illustrated by the following examples: Let point A, Figure 2, represent soil material composed of 28 per cent sand, 33 per cent silt, and 39 per cent clay. The location of A indicates that the material is clay. Let point B represent a soil material composed of 63 per cent sand, 24 per cent silt, and 13 per cent clay. The position of B indicates that it represents a sandy loam. A sandy loam may be a fine sandy loam, a coarse sandy loam, or a very fine sandy loam, depending on the predominance of fine or coarse sand.

The limits in the diameter of the particles in the different grades of material or separates, as determined in mechanical analysis by the Bureau of Soils, are as follows: Fine gravel, or very coarse sand, from 2 to 1 mm.; coarse sand, from 1 to 0.5 mm.; medium sand, from 0.5 to 0.25 mm.; fine sand, from 0.25 to 0.1 m.; very fine sand, from 0.1 to 0.05 mm.; silt, from 0.05 to 0.005 mm.; and clay below 0.005 mm. in diameter. In order to represent on a triangular diagram the proportions of the 3 main mechanical constituents of a soil, the different grades of sand must be combined. Accordingly, the previously mentioned range in diameter for the sand, silt, and clay has been used, as follows: Sand, from 2 to 0.05 mm.; silt, from 0.05 to 0.005 mm.; and clay, below 0.005 mm. Thus the 5 grades of sand determined in mechanical analysis are combined and are considered as one class of constituent.

ITS APPLICATION TO FIELD PRACTICE

Several considerations should be noted in determining soil classes in field practice. One is the moisture condition of the soil. It is often very difficult, and sometimes impossible, to judge the texture of a soil in the field when it is either so wet as to be decidedly sticky or so dry as to make it difficult to obtain samples with a soil auger. Thus it may be necessary to allow a sample to dry partly or to add water to it before its texture can be determined. Soil is in the best condition to be judged for texture when it contains the optimum moisture for plant growth or tillage operations, that is, when it contains enough moisture to impart moderate pliability, in the case of clays, and good friability, in the case of all other soils which do not permit of easy textural distinctions. This optimum condition is not always found in the field, and it is not easily determined, so that much field experience with soils of many types is necessary before the examiner can depend upon his judgment. When in doubt, the field man should send representative samples to a laboratory for analysis.

DIFFICULTIES TO BE OVERCOME

When the thin top layer of a virgin soil differs in texture from the underlying layer a class distinction may be made by determining the texture of a mixture of the layers, such as would result in plowing. For example, if the top layer of a virgin soil is a fine sandy loam from 1 to 2 inches thick, and immediately beneath it is a 4-inch or 5-inch layer of material having a clay-loam texture,

the soil would be called a sandy clay loam, as this would approximate the texture if the layers were mixed when plowed at ordinary depths.

Sometimes the class indicated by field examination may not correspond with the designation reached by mechanical analysis because of the character of the sand grains. An example of this is furnished by the wind-blown material derived from gypsum in Reeves County, Tex. Field observations of the texture lead to the conclusion that this soil is decidedly sandy, and in the field it should be so designated. But when the sample is rubbed gently, the somewhat hardened fragments break into separate particles, many of which have the dimensions of clay particles.

The shape of the sand grains sometimes influences the "feel" of the material and leads to erroneous judgment. Sharp grains, for instance, might give a feeling of roughness that might create a wrong impression of the coarseness of the material. A grating sound of the sand grains generally indicates sharp edges and not necessarily coarseness. Sometimes the sound caused by the friction of sand grains does not indicate that the separate grains have sharp edges, as in the case of "singing sands." Such sands, occurring in places where sediments are subjected to water action, consist of water-worn and more or less rounded particles, like the sand deposited along certain streams of the Atlantic coastal plain and on the shores of Lake Michigan. Sands of the Atlantic and Gulf coastal plains, as those of the Norfolk series of soils and often desert dunesands, have rounded particles, whereas sands in other parts of the country usually have angular grains. Angular-grained sands have a definite commercial value. These different kinds of sand present a study in themselves. They are of interest here merely because they may be found in soil surveying.

It should be emphasized that most virgin soils are designated by class names, as loam and silt loam, because of the textural character of their surface layers. This rule, however, is not always rigidly adhered to. Some of the sandy loams, such as those of the Orangeburg and Norfolk series, often represent arbitrary designations based on the fact that the moisture behavior of the soil is a resultant of the joint functioning of the surface and subsoil layers, when neither layer has a sandy-loam texture. Frequently the thin surface portion of a virgin soil is a loamy sand or a loamy fine sand, and the layer immediately beneath has a sandy clay or a sandy clay loam texture. Sandy clay material seldom constitutes a surface layer, but it usually occurs as a layer immediately beneath a sandy surface layer. The mixture of the two layers by plowing, however, gives a soil material which has been satisfactorily classed as sandy loam.

The physical properties of certain fine chalklike materials do not always accord with those of most soil materials which have a similar content of fine particles. For example, although fine grained and often somewhat indurated and compact, the materials composing the soft beds of caliche found in the western dry regions of the United States and the chalk formations under the calcareous soils of the black prairies of Alabama and Mississippi and parts of the black waxy belt of Texas, seem to be more porous and friable than most soil materials of similar texture.

Soils with a high content of lime carbonate sometimes assume on drying a degree of pulverulence that gives a deceptive "feel," especially the calcareous clays of the Great Plains, the dry surface material of which in many places appears to have the character of a loam.

Soils with considerable micaceous material have a decidedly unctious, or greasy feel, especially in case of the clays. As a rule the more sandy soils belong to the group of loose or highly friable soils, although instances may be cited of soil material containing from 40 to 50 per cent of sand and intimately mixed with plastic clay which is as stiff as exceedingly heavy clay. On the other hand, clay soils which are as friable as soils of high sand content are frequently found, especially in the Tropics.

Certain well-weathered clays of extremely fine texture in tropical regions, such as the Matanzas and Nipe clays of Cuba, are very much more pervious to water and less sticky when wet than soils of similar texture in temperate zones, where, presumably, weathering has not advanced so far (*3*). The average Matanzas clay is heavier in texture than any soil of the United States, but it is so permeable that practically all rain water passes through it at a rapid rate. The annual precipitation is often more than 50 inches, yet the land can be plowed the day after an extremely heavy rain. The total absence of stream channels on areas of this soil shows the almost complete absence of run-off. The Nipe clay of eastern Cuba has a clay content of nearly 50 per cent. Nevertheless, in a locality where the rainfall is well above 50 inches, this soil is so pervious that there is no evidence of erosion, and pick marks made in vertical walls of it may remain for years. The peculiar character of these and similar clay soils developed in warm climates are associated with a predominance of iron and aluminum in the soil colloid and with a flocculated condition of the colloidal material. The flocculated condition of the colloidal material gives the soil a large pore space and high permeability. Some of these tropical clays are as friable as sand.

The presence of much organic matter in a soil so alters its qualities that sometimes only with difficulty can its class be satisfactorily determined in the field. The organic material tends to conceal the true proportions of the inorganic particles.

In the field it is often difficult to distinguish between loam and sandy loam, loam and fine sandy loam, silt loam and silty clay loam, and loam and silt loam, especially when one material approaches the other in composition. In soil mapping, the less experienced field men frequently send to the laboratory "loam" samples which mechanical analysis show to be silt loams or very fine sandy loams. Such analyses show that the soils concerned are near the boundary line between a loam and a silt loam or sandy loam, so that if they were called loams the error would be so slight as to make but little practical difference.

Probably the most difficult of all soil classes to determine are the clay loams and the very fine sandy loams. Clay loams are frequently found on slopes where erosion has caused patchy occurrences of soils of various textures. Furthermore, soils on the eroded or overwashed areas tend to bake so hard as to render it difficult to determine their actual composition in the field. Very fine sandy loams generally contain much silt and exceedingly fine sand, and the texture of a

mixture of these materials is more difficult to determine than that of most other mixtures. Both clay loams and very fine sandy loams are found extensively on alluvial plains and on the wind-swept prairies and plains of the central part of the United States, where mixing by wind and overflow water is common.

Precautions are necessary in gathering soil samples. Unsuitable spots should be avoided, such as places where the natural soil may have been disturbed, and roadside strips, where the natural characteristics may have been altered by traffic, wind, or water. No sampling should be done at any place of possible accidental contamination. Experienced men have no difficulties with these possible sources of error.

The foregoing examples illustrate the care that must be taken in determining the class to which a soil belongs. The difficulties cited are exceptional and may be overcome in most cases by care in judging the mechanical composition of a soil material.

In general, experienced field men examining soils over widely separated areas are able to judge the soil classes in a way that conforms satisfactorily to the mechanical compositions determined in the laboratory.

CLASSIFICATION OF SOILS BASED ON MECHANICAL COMPOSITION

A classification of all the principal and subordinate soil classes, as determined by mechanical composition, follows. As may be noted, there are 20 of these classes. The soils of the various classes are gathered into three major groups according to their clay content. The composition of some special soils is also given.

1. Soils containing less than 20 per cent clay:
    - Soils containing less than 15 per cent silt and clay—
        - Sand:
            - Coarse sand (35 per cent or more fine gravel and coarse sand, and less than 50 per cent fine or very fine sand).
            - Sand (35 per cent or more fine gravel, coarse and medium sands, and less than 50 per cent fine or very fine sand).
            - Fine sand (50 per cent or more fine and very fine sands).
            - Very fine sand (50 per cent or more very fine sand).
    - Soils containing from 15 to 20 per cent silt and clay—
        - Loamy sand:
            - Loamy coarse sand (35 per cent or more fine gravel and coarse sand, and less than 35 per cent fine and very fine sand).
            - Loamy sand (35 per cent or more fine gravel, coarse, and medium sands, and less than 35 per cent fine and very fine sand).
            - Loamy fine sand (35 per cent or more fine and very fine sands).
            - Loamy very fine sand (35 per cent or more very fine sand).
    - Soils containing from 20 to 50 per cent silt and clay—
        - Sandy loam:
            - Coarse sandy loam (45 per cent or more fine gravel and coarse sand).
            - Sandy loam (25 per cent or more fine gravel, coarse and medium sands, and less than 35 per cent very fine sand).
            - Fine sandy loam (50 per cent or more fine sand, or less than 25 per cent fine gravel, coarse and medium sand).
            - Very fine sandy loam (35 per cent or more very fine sand).
    - Soils containing 50 per cent or more silt and clay—
        - Loam and silt loam:
            - Loam (less than 20 per cent clay, from 30 to 50 per cent silt, and from 30 to 50 per cent sand).
            - Silt loam (less than 20 per cent clay, 50 per cent or more silt, and less than 50 per cent sand).

2. Soils containing from 20 to 30 per cent clay:
   Clay loam:
   - Sandy clay loam (less than 30 per cent silt, and from 50 to 80 per cent sand).
   - Clay loam (from 20 to 50 per cent silt, and from 20 to 50 per cent sand).
   - Silty clay loam (from 50 to 80 per cent silt, and less than 30 per cent sand).
3. Soils containing 30 per cent or more clay:
   Clay:
   - Sandy clay (from 30 to 50 per cent clay, less than 20 per cent silt, and from 50 to 70 per cent sand).
   - Clay (30 per cent or more clay, less than 50 per cent silt, and less than 50 per cent sand).
   - Silty clay (from 30 to 50 per cent clay, from 50 to 70 per cent silt, and less than 20 per cent sand).

SPECIAL SOILS

Peat (65 per cent or more organic matter, sometimes mixed with considerable sand, silt, and clay).

Peaty loam (from 20 to 25 per cent organic matter mixed with much sand and silt, with but little clay).

Muck (from 25 to 65 per cent well-decomposed organic matter, mixed with much clay or silt and some sand).

Gravelly soil (30 per cent or more fine, medium, and coarse gravel particles or stones varying up to 4½ inches in diameter).

Stony soil (enough stones over 4½ inches in diameter to interfere with cultivation).

SUMMARY

The proportions of sand, silt, and clay of a sample of soil can not be shown on a right-angled diagram.

The mechanical composition of the main soil classes may be graphically indicated on an equilateral triangle by showing their percentage composition of sand, silt, and clay.

The proposed diagram is an improvement over the earlier ones of the Bureau of Soils, in that it includes the proportion of sand, as well as of silt and clay. On the earlier diagrams it was necessary to determine the third component from the other two.

The limits accepted for sand, silt, and clay in the textural classes of soils conform to the judgment of the field men.

Twenty principal and subordinate soil classes based on mechanical composition are recognized. These may be grouped into three major classes according to their clay content.

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